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+ A revision of the genus *Paracinema* Fisch. (Orthoptera). By
K. H. L. KEY, M.Sc. pp. 379-400

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A REVISION OF THE GENUS *PARACINEMA* FISCH. (ORTHOPTERA)

By K. H. L. KEY, M.Sc.

[Read 4th March, 1936.]

WITH THREE TEXT-FIGURES AND A MAP.

UNTIL quite recently five species of the above genus were recognised. These were: *tricolor* Thunb., *luculenta* Karsch, *superba* Bol., *terminale* Bol., and *guilielmi* Sjöst. Kirby's synonymy of the species of the earlier authors with *tricolor* was generally accepted. Latterly Sjöstedt (1929) has synonymised his species *guilielmi* with *luculenta*. With this synonymy I concur. Though I have not seen the types, it seems impossible, in the light of my studies on a very long series of *tricolor*, to regard Bolivar's two species as distinct from *tricolor*, and I have therefore synonymised these three species.

Thus only two species remain, viz., *P. tricolor* Thunb. and *P. luculenta* Karsch. In *P. tricolor* I have distinguished several subspecies.

Key to the species of *Paracinema*.

1. Lateral pronotal fasciae absent; anterior lateral carinae obsolescent, not reaching more than half-way to the first transverse sulcus, or quite obsolete; general coloration dark yellow-green . . . *P. luculenta* Karsch.
- 1.1. Lateral pronotal fasciae present; anterior lateral carinae always present, though often very feebly developed, and reaching the first transverse sulcus; general coloration paler *P. tricolor* Thunb.

P. luculenta Karsch.

P. luculenta Karsch, 1896, *Stettin. ent. Ztg.*, 57 : 254.

P. guilielmi Sjöst., 1923, *Ark. Zool.*, 15 (6) : 16, pl. 1. f. 1 and 2; 1929, *loc. cit.*, 20 (A), 15 : 6.

Karsch's description of this species contains all the crucial points of difference from *tricolor*, which are those given in the key to the species set out above. On the other hand, his description of the colour of the hind femora, as pointed out by Sjöstedt, is incorrect, and other points in his description do not seem to be essential. Thus in the series before me the antennae reach beyond the hind margin of the pronotum in the female, and the sulci and puncturing are not deeper than in many specimens of *tricolor*.

I have compared a series of nine males and three females from West Africa (British Museum collection) with Sjöstedt's type. There is no doubt about the shortness of the wings of Sjöstedt's specimens, and there are also other slight differences. The eyes in *guilielmi* are less globose than in the specimens from W. Africa, and the head is slightly narrower. The wings are more infumate, and are not bluish basally; the fastigium is less rounded apically, and the head less convex. However, in the matter of globosity of eyes, convexity of head and shape of fastigium, there is considerable variation among the specimens from West Africa, and in the matter of wing length and size, the condition in Sjöstedt's male is also very closely approached by a specimen from Gold Coast. Sjöstedt himself has synonymised his species with *luculenta* on the basis of a series connecting his type with Karsch's, and there is

therefore the possibility of separating subspecies, but I do not propose to do this with the scanty material to hand.

Only green forms of this species are known to me.

P. tricolor Thunb.

Gryllus tricolor Thunb., 1815, *Mem. Acad. Petersb.*, 5 : 254; 1824, 9 : 398; 419, n. 72.

P. tricolor Stål, 1873, *Recens. Orth.*, 1 : 91, 103.

G. bisignatus Charp., 1825, *Hor. ent.* : 133.

Acridium viridulum Costa, 1836, *Faun. Nap., Ortott.* : 33, n. 15, pl. 5.

Oedipoda virescens Luc., 1849, *Expl. Alg.*, 3 : 37, n. 62, 4, pl. 4, f. 4.

G. sylvestris Thunb., 1815, *loc. cit.* : 255; 1824, 9 : 398, 420.

P. superba Bol., 1905, *Mem. Soc. Espan.*, 1 : 223.

P. terminale Bol., 1908, *Mem. Soc. ent. Belg.*, 16 : 100, n. 69.

I have been able to examine a very long series of over 500 specimens of *P. tricolor*, collected from the whole of Africa, including Madagascar, and from the south of Europe. The examination has revealed a fair constancy of characters in specimens from the same locality, but an extremely wide variation as between specimens from different localities. This variation involves a large number of morphological characters, such as shape of head, length of wings, and to a lesser extent some colour characteristics, such as the colour of the inner surface of the hind femur. On the whole, however, colour is fairly constant as compared with many other ACRIDINAE, except that occasionally grey-brown forms appear instead of the usual green form.

In spite of the great extremes of geographical variation in morphological characters, numerous intermediate forms appear, and it does not seem possible to separate species. In such a widely-distributed species as *P. tricolor*, however, it is clearly desirable that these morphological races, in so far as they are fairly constant within a given locality, should receive definite recognition for purposes of reference. I propose, therefore, to describe as subspecies the most distinct forms, and to refer briefly to intermediate or less well-defined forms. I have no confidence in the validity as distinct species of *P. superba* Bol., and *P. terminale* Bol. Each was described from one female only, and there are specimens in my series which would roughly fit both descriptions. Every character which Bolivar considers characteristic of his species may be found, in various combinations, in my series.

The characters separating the subspecies are often best seen in the males, while sometimes the variation does not take the same direction in the two sexes. No attempt is made at full descriptions: since the subspecies intergrade, such descriptions would be unnecessary and misleading. The descriptions refer, in each case, to the whole series which is considered typical of the subspecies, and not to the particular specimen selected as type. Only the main distinguishing features are mentioned, and most of these are of a relative nature.

An attempt has been made to represent some of these relative differences numerically by the method of biometric analysis, which has already been applied to the ACRIDINAE by Uvarov, in connection with the determination of the phases in locusts. The methods employed in this analysis, and the use of the biometric data as a means of separating the subspecies, are discussed on p. 396.

Key to the subspecies of *P. tricolor* Thunb.

Explanation of the ratios used will be found on p. 398. Where three figures are given for a ratio, the first is the minimum, the second the average, and the third the maximum.

1. E/C within the range 4.8-5.5.

2. Hind tibia in male entirely bright red, little expanded apically; pronotum with lateral carinae obsolescent, lateral fasciae reaching hind margin; femora yellow in infero-internal and interno-median area; L/P: 1.26, 1.43, 1.53; P/B: 2.57, 2.89, 3.02 *P. t. sylvestre* Thunb.

1.1. E/C within range 5.6-7.2.

2. Pronotum long, rather pointed behind, with the surface raised in the neighbourhood of the carinae, not level, anterior parts of lateral carinae converging considerably backwards. Space between lateral fasciae narrow. P/B: 3.33, 3.81, 4.31.
3. Large subspecies; L/P: 1.13, 1.29, 1.41; E/C: 5.90, 6.56, 7.00. Lateral fasciae not reaching hind margin of pronotum; hind tibiae in male entirely red.
P. t. bisignata Charp.

2.2. Pronotum smaller, less pointed behind, little raised in neighbourhood of carinae, relatively level, anterior parts of lateral carinae parallel or only slightly converging backwards; space between lateral fasciae broad. P/B: 2.64-3.72.

3. Hind femora red in infero-internal and interno-median areas, frequently with black markings as well on the interno-median area.
4. Medium-sized. E/C: 5.67-7.20; P/B: 2.66-3.72; L/P: 1.29-1.61; wings pale blue basally *P. t. madecassa* subsp. n.

3.3. Hind femora usually yellowish, at most amber, in infero-internal and interno-median areas, without black markings (sometimes black markings in the brown forms).

4. Small in size, head very small; fastigium long; antennae very short, the joints not longer than broad; L/P: 0.82, 1.17, 1.37; E: 23.0, 24.85, 27.0.
5. Hind tibiae in male entirely red; E/C: 5.80, 6.20, 6.51 *P. t. montana* subsp. n.

4.4. Large in size; head not very small; fastigium of medium length; antennae very long, the joints about twice as long as broad; L/P: 1.36-1.97; E: 31.1-39.5.

5. Hind tibiae in male never entirely red; usually reddish apically, and sometimes less so basally. General coloration (in the green forms) pale blue-green, more or less invaded by buff . . . *P. t. sudanensis* subsp. n.

5.5. Hind tibiae in male entirely red. General coloration (in the green forms) a darker, less bluish green, not invaded by buff *P. t. tricolor* Thunb.

Paracinema tricolor tricolor Thunb.

Gryllus tricolor Thunb., 1824, *Mem. Acad. Petersb.*, 5 : 254; 1815, 9 : 398, 419, n. 72.

P. tricolor Stål, 1873, *Recens. Orth.*, 1 : 91, 103.

P. superba Bol., 1905, *Mem. Soc. Espan.*, 1 : 223.

P. terminale Bol., 1908, *Mem. Soc. ent. Belg.*, 16 : 100, n. 69.

Thunberg's original description of *Gryllus tricolor* is very incomplete, and could apply to all of the subspecies. The record of the type from China is very doubtful, and the locality is probably African, especially since *G. sylvestris*, described at the same time, is correctly recorded from South Africa. Examination of the type will probably show that it belongs to the most widespread African subspecies, which I therefore describe as *P. t. tricolor*.

♂ (fig. 1, B; fig. 2, B and Da; fig. 3, B). Large and slender. Antennae much longer than head and pronotum together, varying in depth of colour. Head relatively large, on top only slightly convex forwards and sideways. Fastigium narrow at the base, slightly longer than its width between the apex of the eyes, only slightly reclinate, considerably impressed. Eyes rather narrowly separated on top : therefore fairly prominent from above, and the upper margins running parallel for some distance before diverging backwards. Head in profile hardly sloping forward above, relatively level, including the fastigium; face strongly sloping, nearly straight; genae not particularly prominent. Frontal ridge variable, but typically with fairly broad, blunt margins, converging gradually to the base of the antennae, and then more rapidly to the fastigium; not meeting the fastigium sharply, moderately deeply impressed. Pronotum widening slightly backwards, slightly constricted in the middle, little pointed behind; on top relatively broad, the surface little raised in the neighbourhood of the carinae, relatively smooth and level, the puncturing in the metazona fairly fine; anterior lateral carinae usually slightly converging backwards. Lateral pronotal lobes hardly impressed. Elytra and wings relatively long and narrow, reaching, typically, a considerable distance beyond the apex of the abdomen and hind femora. Inner knee lobes sharply pointed. Sides of head, lateral lobes of pronotum (especially in the prozona) and pleura, dull, not shiny. Hind tibiae well expanded apically. General coloration dull green. Top of head and disk of pronotum between the lateral fasciae velvety green, sometimes with a touch of brown. Lateral fasciae often, though not always, fading out in about the middle of the metazona, without reaching the hind margin of the pronotum. The space between them broad. Wings faintly milky blue basally. Hind femora yellowish or sometimes slightly amber in the infero-internal and interno-median areas. Knees variable in colour, not very dark, the inner knee lobes at least, and sometimes other parts, red. Hind tibiae, with the exception of the spines, always entirely bright red. More or less uniformly brown forms occur occasionally. In these the infero-internal and interno-median areas of the hind femora are somewhat reddish.

♀. Considerably larger than the male. Fastigium much shorter and broader than in the male, the lateral angles sharp. Eyes not as prominent on top as in the male. Face less strongly sloping than in the male. Elytra relatively broader than in the male. Occasionally the hind tibiae are not red right up to the base, the basal part being then yellowish-green. E/C and L/P very high; P/B moderate (see p. 397).

Measurements : See p. 397.

Described from 19 quite typical males and 22 typical females from my own collection and those of the British Museum and the South African Museum. The following are the localities :—

♂♂. "South Africa" (1), Seymour, Eastern Cape Province (32. 6 S., 26. 7 E.) (1), Somerset East, Eastern Cape Province (32. 7 S., 25. 6 E.) (1), Port St. Johns, Pondoland (31. 6 S., 29. 5 E.) (5), Bizana District, Pondoland (31. 1 S., 30. 2 E.) (5), Durban, Natal (2), Weenen, Natal (28. 8 S., 30. 1 E.)

(2), Bethlehem, Orange Free State (28. 1 S., 28. 3 E.) (1), Salisbury, S. Rhodesia (17. 8 S., 31. 0 E.) (1).

♀♀. "South Africa" (2), Somerset East (2), Port St. Johns (3), Knysna, C.P. (34 S., 23 E.) (2), Kleinemond, S. Africa (1), Bizana District, Pondoland (3),

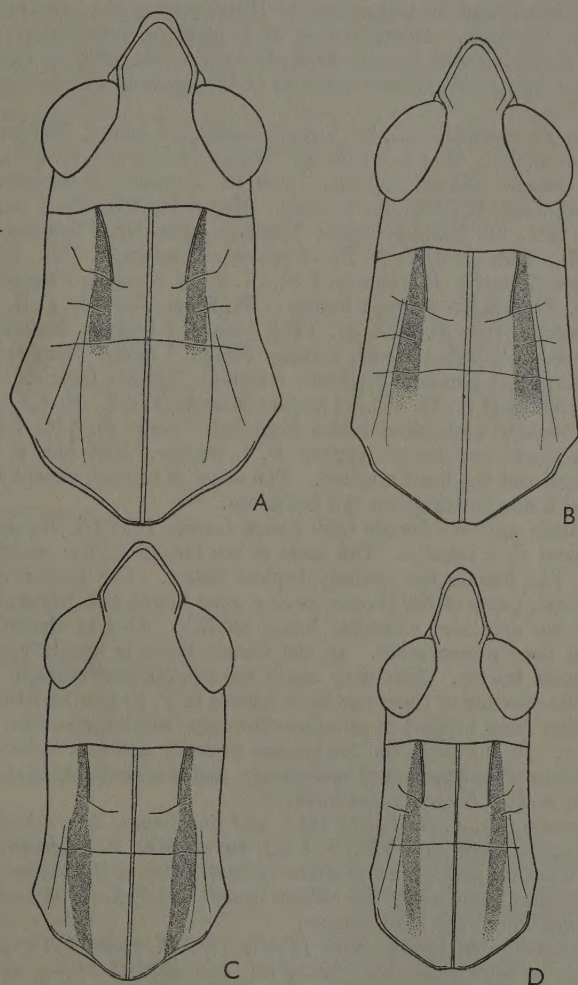


FIG. 1.—*Paracinema tricolor* subsp. (A) *bisignata*, (B) *tricolor*, (C) *sylvestre*, (D) *montana*.

Katberg, C.P. (32. 5 S., 26. 6 E.) (1), Durban, Natal (1), Bloemfontein, Orange Free State (29. 1 S., 26. 2 E.) (1), Harrismith, O.F.S. (28. 2 S., 29. 1 E.) (1), Pretoria, Transvaal (25. 6 S., 28. 1 E.) (1), Salisbury, S. Rhodesia (1), Waterberg, South West Africa (20. 5 S., 17. 5 E.) (1), Mastene, Portuguese East Africa (1), Fort Johnston, Nyasaland (14. 5 S., 35. 1 E.) (1).

Other series of, or close to, *P. t. tricolor*.

(1) A long series of specimens from Uganda and a few from Kenya are almost typical *P. t. tricolor*, but the eyes are slightly more close-set than in the typical specimens. Of these, 10 males and 7 females are from the British Museum collection, and 69 males and 14 females from the private collection of Mr. H. B. Johnston. Another male of Johnston's from Rejap, Mongalla, Sudan (4. 7 N., 32 E.), also belongs here, showing no tendency to vary towards *P. t. sudanensis* (q.v.) The exact localities of the specimens in this series are as follows:—

UGANDA: Entebbe (0. 1 N., 32. 5 E.), 8 males, 5 females; Mabira Forest, 2 males; Mwera (0. 2 N., 32. 1 E.), 1 female; Buruli, Sezibwa R. (0. 2 N., 32. 5 E.), 8 males, 1 female; Kigezi, Butale, 7,000 ft., 3 males, 2 females; Kigezi, Kamuganguzi, 7,000 ft., hill-top, 2 males; Kigezi (1. 3 S., 29. 7 E.), 1 male; Kampala (0. 2 N., 32. 5 E.), 9 males; Namave, 23 males, 2 females; Eastern Prov., 1 male; Lira (3. 5 N., 33 E.), 4 males; Paranga (2. 7 N., 32. 9 E.), 2 males; Zango, 3 males; Bukuya (0. 7 N., 31. 8 E.), 3 males, 1 female; Kakumiro (0. 6 N., 31. 3 E.), 3 males, 1 female; Mt. Elgon, 5,000 ft. (1 N., 34. 5 E.), 1 male, 1 female; Toro (0. 5 N., 30. 5 E.), 1 male, 1 female; Bombo (0. 5 N., 32. 5 E.), 1 male; Adachel-Joroti, 1 male; Nsagu, 1 male; Namataba Forest, 1 female; Terinyi, 1 female; Bugwere, 1 female; Tero, 1 female.

KENYA: Thika (1 S., 37. 1 E.), 2 males; Kabete (1. 2 S., 36. 7 E.), 1 female. (2) Two slightly undersized males from San Thomé (0. 5 N., 7 E.), 1919–1921 (*H. J. Snell*) are almost typical *P. t. tricolor*. The one is valueless, having no legs, and the head crushed. The other is typical, except for a faint suggestion of a median ridge on the fastigium.

(3) One male and one female from Sierra Leone, 1926 (*E. Hargreaves*) are entirely typical *P. t. tricolor*. The male is the largest in the whole series of *P. tricolor*. The female has entirely typical ratios. The colour in both is badly preserved, parts of the thorax having gone black, also parts of the hind femora and the eyes and antennae being reddish. This is almost certainly the result of poor preservation. In the female there is hardly any trace of lateral pronotal fasciae. This may again be due to preservation, but even if it is not, the absence of these fasciae is known in *P. tricolor* also from Tenenkau, when they were present in an otherwise quite similar specimen from the same locality. In the male the fasciae are present, and end before the hind margin. Colour is best preserved in the male, and it is probable that both were quite typical of *P. t. tricolor* when fresh.

(4) One male (*Dr. L. H. Booth*) 1914, and one female (*H. Strachan*) 1900, both from Lagos, Nigeria (6. 3 N., 3. 3 E.), are close to *P. t. tricolor*, but both agree on two points which are not quite typical. One is the rather short and rounded fastigium, the other the rather broad and definite lateral pronotal fasciae, ending before the hind margin.

(5) A yellow-brown female from Liberia (*W. P. Lowe*) 1912, near to *P. t. tricolor*, has a somewhat short fastigium, and only the apex of the hind tibiae reddish, but agrees in the ratios.

(6) A rather more different series from Tanganyika, consisting of 20 males and 2 females from Tukuyu, 5,084 ft., collected from July to December 1923 by *N. C. E. Miller*; 1 male from Tubugwe (Oct. 1926, *Miller*); 1 male from Bukoba (1. 3 S., 31. 8 E.) (Dec. 1921, *Miller*); and 1 female from Morogoro (Dec. 1920, *Miller*). The males differ from typical *P. t. tricolor* in their size, which, though variable, is on the whole considerably smaller. The wings are somewhat shorter, the head narrow, but in profile

usually quite considerably convex, the pronotal disk often more or less concave. The hind tibiae are often not as expanded apically as in typical *P. t. tricolor*, and the lateral pronotal lobes are somewhat impressed. Margins of fastigium clear-cut. All the above characters are very variable throughout the series, and are neither constant enough nor considerable enough to make the creation of another subspecies worth while. In spite of the convergence of several characters towards *P. t. sylvestre*, there can be no question of this series being at all intermediate between *t. tricolor* and *sylvestre*. The slight build, narrow head and close-set eyes show it to be very close to *P. t. tricolor*.

The two females from Tukuyu are grey-brown forms, rather below average size, and with the infero-internal area of the femur reddish, as is usual in the

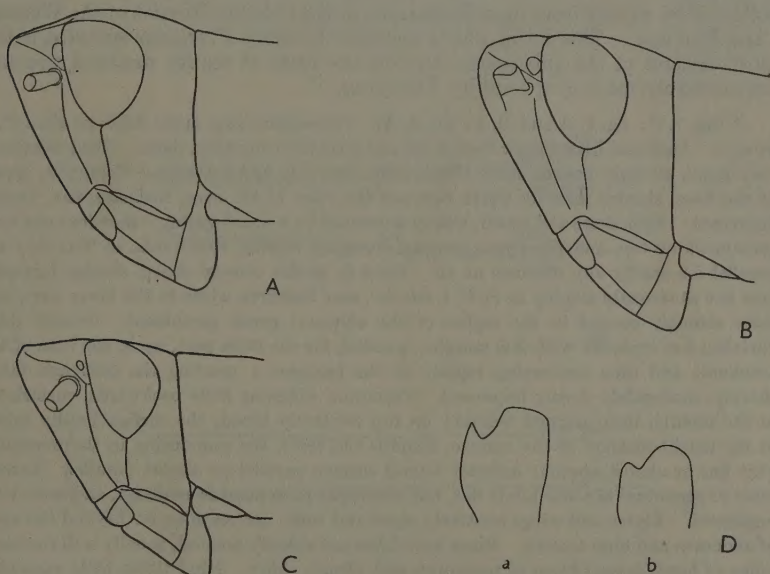


FIG. 2.—*Paracinema tricolor* subsp. (A) *sylvestre*, (B) *tricolor*, (C) *montana*, (Da) *tricolor*, (Db) *sylvestre*.

brownish forms, but otherwise not differing from typical *P. t. tricolor*. The female from Morogoro is typical in all respects, except that the infero-internal, and part of the interno-median areas are strongly reddish, approaching very nearly the condition in the series of *P. t. madecassa* from Manera, and supporting the view that this character could not be used to separate *P. t. madecassa* specifically. Identical with this series from Tanganyika are two females from River Lubudi, Katanga, Congo (24. 6 E.) (Nov. 1927, Dr. M. Burr) and one male from Nasantoye (10. 4 S., 25. 1 E.) (Nov. 1927, Burr). In the male the lateral fasciae reach the hind margin of pronotum, in the female they do not.

(7) A female with hardly any trace of lateral fasciae, from Fort Johnston, Nyasaland. In other respects typical.

(8) One male and one female from "Congo" (C. L. E. Andreae), 1900, both poorly preserved, are very near to *P. t. tricolor*, but the fastigium is slightly smaller than the average.

(9) A few other miscellaneous specimens not quite typical, from:—Zanzibar, Delagoa Bay (32. 7 E., 26 S.), Lake Zambesi, Mombasa (4. 2 S., 39. 8 E.), "E.-C. Africa," Mouth of Zambesi.

All these specimens are badly preserved, most having been preserved in alcohol, with the result that they have become much shrunk, and almost completely decolorised.

Paracinema tricolor sylvestre Thunb.

Gryllus sylvestris Thunb., 1815, *Mem. Acad. Petersb.*, 5: 255; 1824, 9: 398, 420.

I have examined Thunberg's type of *P. sylvestre*, which has been rightly synonymised with *P. tricolor*, and find that it is identical with a form of *tricolor* collected by myself from near Hermanus, in the Caledon District of the Western Cape Province. This form, which therefore becomes *P. tricolor sylvestre*, is the most distinct of the subspecies, and on the basis of scanty material was not unreasonably made a species by Thunberg.

♂ (fig. 1, C; fig. 2, A and D, b; fig. 3, A). Of medium size, more thick-set than *P. t. tricolor*. Antennae little longer than head and pronotum together, dark. Head relatively very large, strongly convex from above, both forwards and sideways. Fastigium broad at the base, shorter than its width between the apex of the eyes, reclinate, flat, hardly impressed. Eyes short and broad, widely separated by a broad vertex: therefore not very prominent on top, and the upper margins diverging rapidly backwards, so that they are parallel for hardly any distance at all. Head in profile convex above, sloping forward; face not as strongly sloping as in *P. t. tricolor*, and therefore wider in the lower part, and more strongly curved in the region of the clypeus; genae prominent. Frontal ridge variable, but typically with fine margins, parallel, for the most part, up to the base of the antennae, and then converging rapidly to the fastigium; meeting the fastigium fairly sharply, moderately deeply impressed. Pronotum widening little backwards, constricted in the middle, little pointed behind; on top relatively broad, the surface hardly raised in the neighbourhood of the carinae, smooth and level, the puncturing in the metazona very fine or almost absent; anterior lateral carinae parallel or almost parallel. Lateral lobes of pronotum not absolutely flat, but somewhat prominent from above, and somewhat impressed. Elytra and wings relatively short and wide, not reaching far beyond the apex of abdomen and hind femora. Inner knee lobes not sharply pointed, usually well rounded. Sides of head, lateral lobes of pronotum and pleura, shiny. Hind tibiae little expanded apically. General coloration bright yellow-green. Top of head and disk of pronotum between the lateral fasciae usually dark velvety brown, sometimes velvety (non-shiny) green. Lateral fasciae of pronotum always reaching hind margin; space between them broad. Wings faintly greenish blue basally. Hind femora pale yellowish on the infero-internal and interno-median areas. Knees very dark, the lobes partly reddish. Hind tibiae, with the exception of the spines, always entirely bright red.

♀. Considerably larger than the male. Head from above similar to the male, but typically more convex in every direction, the convexity extending in some cases to the surface of the fastigium itself. The face in profile straighter than the male above the clypeus. Resembling the male in the other main features. E/C quite characteristic for the subspecies, the whole range being below the minimum for any other subspecies; L/P moderate; P/B the lowest of any subspecies, but the only subspecies with which there is no overlapping is *P. t. bisignata* (see p. 389).

Measurements: See p. 397.

Described from 12 typical males, 11 from near Hermanus, Caledon District, S.-Western Cape Province (34. 4 S., 19. 3 E.) (my own collection), and

1 from "South Africa" (British Museum Coll.); and 12 females, 11 from near Hermanus (my coll.), and 1 from Stellenbosch, S.-W. Cape Province (S. African Museum coll.) (33. 9 S., 18. 8 E.).

Other series close to *P. t. sylvestre*.

1 male and 3 females from Deelfontein, Richmond District, Cape P. (31 S., 23. 7 E.), 1903 (Col. Sloggett), are close to *sylvestre* but not quite typical. They are smaller in size, nearly all measurements being below the minimum

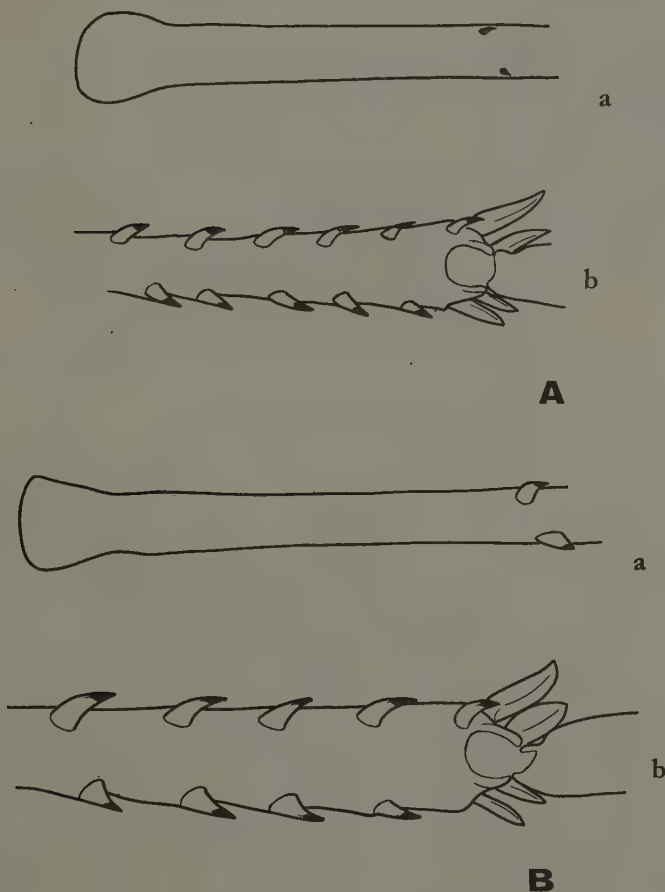


FIG. 3.—*Paracinema tricolor* subsp. (A) *sylvestre*, (B) *tricolor*.

values for *sylvestre*. The head is relatively broad, but not as broad as in typical *sylvestre*, E/C being in two of the three females above the maximum for *sylvestre*, but in only one of the three above the minimum for *P. t. madecassa* (series 2) (*q.v.*), which in this respect is nearest to *sylvestre*. The pronotum

is short, making L/P in two cases higher than the maximum, and P/B in two cases lower than the minimum, *i.e.* the lowest of the whole *tricolor* series. Fastigium in the male longer and narrower, in the females impressed. Head convex, but less so than in typical *sylvestre*. Antennae longer. Inner knee lobes bluntly pointed. Sides of head, lateral lobes of pronotum, and pleura, shiny. Hind tibiae little to moderately expanded apically. Coloration similar to *sylvestre*, but paler. Lateral pronotal fasciae reaching hind margin.

Series definitely intermediate between *sylvestre* and *tricolor* are described on p. 392.

Paracinema tricolor bisignata Charp.

Gryllus bisignatus Charp., 1825, *Hor. ent.* : 133.

Acridium viridulum Costa, 1836, *Faun. Nap.*, *Ortott.* : 33, n. 15, pl. 5.

Oedipoda virescens Luc., 1849, *Expl. Alg.*, 3 : 37, n. 62, 4, pl. 4, f. 4.

While Thunberg's description of *Gryllus tricolor* refers to *P. t. tricolor*, three other descriptions, correctly synonymised with *P. tricolor*, refer to a European subspecies represented in the material before me by specimens from various southern European localities, and from Algeria. This is clear both from the descriptions and figures. The descriptions referred to are those of *Gryllus bisignatus* Charp., *Acridium viridulum* Costa, and *Oedipoda virescens* Lucas. In all three cases the lateral pronotal fasciae are stated not to reach the hind margin of the pronotum, and the wings are greenish basally. The localities are respectively, "Spain and S. France," "all Europe," and La Calle, Algeria. Lucas states that he has seen the same insect from St. Louis, Senegal, but this was probably *P. t. tricolor* or *P. t. sudanensis*. The subspecies takes Charpentier's name *bisignata*.

♂ (fig. 1, A). Large and heavily built, broad across the thorax. Antennae little longer than head and pronotum together. Head on top usually strongly convex forwards, less so sideways. Fastigium variable, narrower at the base than in *sylvestre*, but usually broader than in any other subspecies; reclinate, little impressed, usually longer than its width between the eyes. Eyes variable, usually more widely separated on top than in *t. tricolor*, but less so than in *sylvestre*. Head in profile convex above, sloping forward; face not strongly sloping, straight, or even slightly indented at the median ocellus, usually meeting the fastigium sharply; genae not particularly prominent. Frontal ridge deeply impressed, with fine margins converging gradually to the base of the antennae, and then more rapidly to the fastigium. Pronotum large, long, widening considerably backwards, rather pointed behind; on top, narrow, the surface somewhat raised about the carinae, not as level as in the other subspecies, the puncturing in the metazona somewhat coarse; anterior lateral carinae converging noticeably backwards; the shallow oblique trough which separates the anterior and posterior sections of the poorly developed lateral carinae, and in which the posterior portion of the lateral fascia, when present, lies, more developed than in any other subspecies. Lateral pronotal lobes prominent from above, somewhat impressed. Elytra and wings somewhat intermediate in relative length between *sylvestre* and *t. tricolor*. Inner knee lobes sharply pointed. Sides of head, lateral lobes of pronotum (except sometimes in the hind part) and pleura, dull, not shiny. Hind tibiae moderately to little expanded apically. General coloration green to yellow-green. Head and disk of pronotum between the lateral fasciae sometimes buff to brownish. Lateral fasciae invariably fading out before reaching the hind margin; sometimes only just reaching the metazona, space between them narrow. Wings greenish basally. Hind femora pale yellowish in the infero-internal and interno-median areas. Knees variable in colour, not

very dark; knee lobes red or reddish. Hind tibiae, with the exception of the spines, always entirely bright red. Non-green forms not known.

♀. Considerably larger than the male. Head *less* convex above than in the male (cf. *sylvestre*), much less so than in the female *sylvestre*, hardly different from the condition in the female *t. tricolor*, but base of fastigium slightly broader. Face in profile often slightly indented at the ocellus, as in the male. Pronotum as in the male. Hind tibiae usually entirely red, sometimes not a good red basally. E/C high; L/P low; P/B the highest of any subspecies, but separated completely only from the values for *sylvestre*.

Measurements: See p. 397.

Described from 17 males and 22 females, mostly from the collection of Dr. Burr at the University of Oxford, a few from the British Museum coll. The following are the localities:—Males: Castiletta, B. of Arosa, Spain (*M. Burr*) (7); Gardasse, Sirmione, Spain (*Ramme*) (1); Madrid, Spain (*Bolivar*) (1); Tarbes, France (43. 2 N., 0. 1 E.), (*Pandille*) (1); Dax, Landes, France (43. 6 N., 1 W.), (*M. E. Mosely*) (2); Toulouse, France (*Marquet*) (3); Sardinia, Sorgono (40 N., 9. 1 E.), (*Krausse*) (2); females: Castiletta, Spain (3); Madrid, Spain (1); Oporto, Portugal (8. 5 W., 41. 1 N.) (1); Villalba, Prov. Cuenca, Spain (40. 4 N., 2. 7 W.), (*Uvarov*) (1); Tarbes, France (1); Toulouse, France (3); Monfalcone, Italy (45. 8 N., 13. 5 E.) (1); Corte, Corsica (42. 3 N., 9. 2 E.), (*M. E. Mosely*) (1); Hortiack Plateau, Macedonia (1); Sorgono, Sardinia (8); Setif, Algeria (36. 2 N., 5. 5 E.) (1).

Paracinema tricolor sudanensis subsp. n.

♂. In morphological characters almost identical with *P. t. tricolor*. In most, but not all, of the specimens from the French Sudan, the fastigium is shorter than in *t. tricolor* so that it may be even slightly shorter than its width between the apex of the eyes. This is definitely brought about by the *shorter* fastigium, not by an increased width between the apex of the eyes, which are narrowly separated, exactly as in *t. tricolor*. In the specimens from the Anglo-Egyptian Sudan, and a few of those from French Sudan, the shape of the fastigium is exactly as in *t. tricolor*. Antennae, shape of head, eyes, frontal ridge, lateral pronotal lobes, elytra and wings, knee lobes, absence of shininess, expansion of hind tibiae, exactly as in *t. tricolor*. Pronotum widening little backwards, slightly constricted in the middle, little pointed behind; on top relatively broad, the surface little raised in the neighbourhood of the carinae, relatively level, the puncturing in the metazona somewhat coarse; anterior lateral carinae usually slightly convergent backwards. Typical general coloration pale blue-green, invaded or replaced in parts by pale buff or bluish-buff. In an extreme case of this replacement, from Miyatiki, Middle Niger, the whole body is buff or bluish-buff with the exception of the elytra, the hind part of the metazona of the pronotum, the mandibles, and the apex of the fastigium, which are all very pale blue-green. Darker, brownish forms occur, as in other subspecies. Top of head and disk of pronotum between the lateral fasciae pale blue-green, buff, or brown. Lateral fasciae nearly always fading out in about the middle of the pronotum, without reaching the hind margin; space between them broad. Wings very slightly blue-green basally. Hind femora buff or yellowish in the infero-internal and interno-median areas. Knees usually with little or no red on the inner lobes, not very dark. Hind tibiae never entirely bright red. In one specimen from Sarafere, Middle Niger, there is no red on the tibiae at all, which are pale yellowish. Usually there is a certain amount of red at the apex of the tibia, which disappears as one passes towards the proximal end, where it often reappears just below the knee. The green parts of the elytra very pale blue-green. Anterior lateral carinae of pronotum sometimes pale and callous.

♀. Considerably larger than the male. In morphological features almost identical with

the female *t. tricolor*, differing only in having a fastigium which is on the whole rather shorter, as in the male. The various ratios, as well as the absolute measurements, lie very close to those of typical *t. tricolor*. Pale general coloration less well pronounced than in the male, and brown forms frequent. Lateral pronotal fasciae always fading out before reaching the hind margin. Hind tibiae usually reddish only in a small region at the apex; the colour frequently a very poor red. E/C and L/P high; P/B fairly high.

Measurements: See p. 397.

Described from 15 males, 4 from Khor Wani, Mongalla, Sudan (Feb. 1932, *H. B. Johnston*), kindly loaned by Mr. H. B. Johnston, and 12 from the following localities in French Sudan (*O. B. Lean*):—Saraferé, Middle Niger (15. 7 N., 3. 3 W.), July, 1932 (4); Miyatiki, Middle Niger, May, 1932 (4); Konna, Middle Niger (15. 0 N., 3. 8 W.), July, 1932 (1); Seyna, Middle Niger, June, 1932 (1); Korienze, Middle Niger (15. 3 N., 3. 6 W.), July, 1932 (1); and 18 females, 2 from Khor Wani, Mongalla, and 18 from Middle Niger, French Sudan:—Saraferé (10); Konna (3); Mopti (14. 5 N., 4. 2 W.) (2); Korienze (1).

I have selected as type one of the males from Saraferé; all the other specimens become paratypes. Type and paratypes are in the British Museum, and paratypes have also been deposited with the South African Museum, Cape Town.

Other series of, or close to, *P. t. sudanensis*.

(1) Two males from Kaig in the Sudan (*C. Singer*, March, 1904) are nearly typical. Both are slightly undersized. The one is more or less uniformly buff all over, while the other is greenish-buff, but both may be bleached to some extent. Both have typical hind tibiae.

(2) Rather less typical are two females and a male from Tenekau, Middle Niger (*O. B. Lean*, Sep. 1932). These differ from the typical coloration in being fairly bright yellow-green, and are exceptionally large. The male has lost both hind legs, but the females are typical in the colour of the hind tibiae. In one of the two females there is hardly any trace of the lateral pronotal fasciae, but in the other these are typically developed.

***Paracnema tricolor montana* subsp. n.**

♂ (fig. 1, D; fig. 2, C). Smaller than any of the other subspecies. Antennae at most a little longer than head and pronotum together, frequently equal to, or even less than, head and pronotum together, dark, the longest joints about as broad as long. Head on top only very slightly convex forwards and sideways, small, little extruded. Fastigium narrow at the base, much longer than its width between the apex of the eyes, hardly reclinate, considerably impressed. Eyes narrow, narrowly separated on top: therefore fairly prominent from above, and the upper margins running parallel for some distance before diverging backwards. Head in profile only slightly sloping forwards above; face strongly sloping, nearly straight; genae not at all prominent. Frontal ridge with clear-cut margins converging gradually to the bases of the antennae, and then more rapidly to the fastigium; deeply impressed. Pronotum widening considerably backwards, not at all constricted, little pointed behind; on top relatively broad, the surface little raised in the neighbourhood of the carinae, relatively level, anterior lateral carinae subparallel. Lateral pronotal lobes flat. Elytra and wings relatively short, not reaching far beyond hind knees. Hind femora relatively short. Inner knee lobes fairly sharply pointed. Hind tibiae well expanded apically. Genae, lateral lobes of pronotum, and pleura not shiny. The series is poorly preserved, so that few conclusions as to general coloration can be drawn, except

the negative one that there is no indication that the coloration departs in important respects from that of *P. t. tricolor*. Lateral fasciae of pronotum usually reaching hind margin or near it. Infrero-internal area of hind femur yellow to amber. Knees variable in colour, not very dark. Tibiae, except the spines, entirely red.

♀. Considerably larger than the male. The smallness of the head is very noticeable in comparison with the other subspecies. Antennae always shorter than head and pronotum together. Fastigium much shorter and broader than in the male, but noticeably longer than in any other subspecies. Eyes not as prominent on top as in the male, but considerably more so than in *syvestre*. Elytra and wings only just reaching beyond the hind knees. Lateral fasciae of pronotum usually not reaching hind margin. As a result of the elytra being short and the head small, E/C is not much less than in *t. tricolor*; L/P the lowest of any subspecies, enabling a complete separation to be made from *t. tricolor* and *madecassa* (series 1): P/B medium.

Measurements: See p. 397.

Described from 25 quite typical males from Wouramboulchi, near Djem-Djem, Abyssinia, 9,000 ft. (38 E., 9 N.) (*J. Omer Cooper*), and 15 females from the same locality. A male from this locality has been selected as the type, and deposited, together with paratypes, in the British Museum. Paratypes have also been deposited in the South African Museum.

For specimens intermediate between *montana* and *t. tricolor*, see p. 393.

***Paracinema tricolor madecassa* subsp. n.**

♂. Of variable medium size, on the average somewhat intermediate in size between *P. t. tricolor* and *P. t. syvestre*. Closer to *t. tricolor* than to *syvestre*. Antennae dark throughout, or pale in the basal half. Head and eyes from above similar to *t. tricolor*. Head in profile nearly straight above; face strongly sloping, nearly straight; genae not particularly prominent. Frontal ridge variable, but typically with fairly blunt margins converging gradually to the base of the antennae, and then more rapidly to the fastigium; moderately deeply impressed. Pronotum widening somewhat backwards, slightly constricted in the middle, little pointed behind; on top relatively broad, the surface hardly raised in the neighbourhood of the carinae, smooth and level, the puncturing in the metazona very fine; anterior lateral carinae parallel or almost so; lateral pronotal lobes hardly impressed. Elytra and wings variable in length, on the whole more or less intermediate in length between those of *syvestre* and *t. tricolor*. Inner knee lobes typically pointed, but not as sharply as in *t. tricolor*; fairly blunt knee lobes occur in individuals, especially in the series from Nanisana. Sides of head, lateral lobes of pronotum, and pleura not shiny, or shininess confined to certain parts of the lateral lobes. Hind tibiae moderately to well expanded apically. General coloration non-shiny yellow-green to greenish-yellow. Top of head and disk of pronotum between the lateral fasciae usually bright velvety greenish-yellow, sometimes brownish. Lateral fasciae nearly always reaching, sometimes not quite reaching, the hind margin of the pronotum; the space between them broad. Wings bluish basally, much more so than in *t. tricolor*. Hind femora invariably red in the infrero-internal area, and often in the infrero-external; interno-median area red for the greater part, usually entirely red, and usually with a greater or less amount of dark or blackish coloration along the upper margin. Knees variable in colour, sometimes light, sometimes very dark, and with a variable amount of red on the inner lobes. Tibiae, except the spines, entirely bright red. Brownish forms sometimes occur, but these are more mottled than the uniformly brown forms found in *t. tricolor*.

♀. Considerably larger than the male. Indistinguishable, in the features of the head and pronotum, from the female of *t. tricolor*. In other respects resembling the male, particularly in the characteristic coloration of the hind femur.

I have before me two long and rather different series from Madagascar, both collected by *B. Zolotarevsky*, and a few shorter series which are more or less intermediate, and serve to link up the two longer series. Both main series agree in the essential points of the coloration of the hind femur and wings, though in series (1) the red on the femur is not so characteristically developed as in series (2). Unfortunately series (2) is not as well preserved as series (1), and the specimens appear to be younger adults, so that the apparent colour differences may not be of much significance. The description of the subspecies has been worded so as to apply to all of these series, but the ratios have been calculated separately for each series.

Series (1) comprises specimens from Tulear, in South-West Madagascar, Dec. 1927. The specimens are of medium size, with relatively long wings, giving a high value for E/C, and are mostly strongly yellowish in colour. L/P and P/B both larger than in series (2) (*see p. 398*). In some specimens the red on the femur is not much better developed than in the few exceptional specimens of *t. tricolor* from Tanganyika (*see p. 384*), and black markings in the interno-median area are often absent. All the specimens in series (2) are from Nanisana, Tananarive, Sep. 1928. They are smaller in size than series (1), and the wings shorter, E/C low; L/P and P/B medium. Colour less bright yellow, more green. Red on hind femur well developed, black markings usually present.

The other three series are from Ambohimombo Forest, Antety Mt., and Antongil Bay. All are intermediate between series (1) and (2), a large proportion being dark forms. Measurements and ratios are given for these also (*p. 397*).

Localities :—

Series 1. Maroroky, Ankazoabo, Tulear (23. 3 S., 43. 8 E.), Oct., 1927. 2 males, 5 females. Andronolava, Tongobory, Tulear, Oct., 1927. 12 females. Manera, Tulear, Oct. 1927. 5 females. Ankililoaka, Tulear, May, 1927. 1 female.

Series 2. Nanisana, Tananarive, Sep. 1928. 22 males, 82 females, and nymphs.

Series 3. Ambohimombo Forest, Nov. 1894, and Jan. 1895. 13 males, 13 females.

Series 4. Antongil Bay (N.E. Madagascar) (15. 7 S., 49. 8 E.). 2 males, 2 females.

Series 5. Antety Mt., E. Ambositra. 5 females.

The type is a male from Ambohimombo Forest, and is deposited in the British Museum. Paratypes are deposited in the British and South African Museums.

Intermediate series.

As has already been mentioned, the justification for creating subspecies instead of species lies in the fact that, while the distinguishing characters of the various groups are variable and of a relative nature, the groups are connected by forms which are intermediate in one or more respects, and further that these intermediates occur in localities which are geographically intermediate between the areas of distribution of the main groups. The following are brief descriptions of some of these intermediates :—

I. Intermediates between *P. t. tricolor* and *P. t. sylvestre*.

(a) Two males, one from Harrismith, O.F.S., Feb., 1927 (*R. E. Turner*), and one from New England, C.P., Jan., 1928 (*R. F. Lawrence*) are near to *t.*

tricolor, but show a definite tendency to vary in the direction of *sylvestre*. Head similar to *t. tricolor*, though eyes not quite so narrowly separated. Smaller in size. Antennae long; elytra short; sides of head, pronotum and pleura shiny; hind tibiae little to moderately expanded. Lateral pronotal fasciae reaching hind margin. General coloration of Harrismith specimen olive-green, of New England specimen buff.

(b) Four males and two females from Aliwal North, Eastern Cape Prov. (30. 7 S., 26. 7 E.), 4,350 ft., Jan., 1923 (*R. E. Turner*), are intermediate in size, most measurements being above the maximum for *sylvestre*, and low, in some cases below the minimum, for *t. tricolor*. Antennae in the males long; head and fastigium nearer to *t. tricolor*, though eyes further apart, and head more convex than typical *t. tricolor*. Breadth of head intermediate. For both females E/C lies above the maximum for *sylvestre*; in one it lies below the minimum for *t. tricolor*. Head in females more convex than in males, in one case the convexity extending to the fastigium. Elytra not reaching far beyond hind knees. Inner knee lobes rounded or bluntly pointed. Sides of head, lateral lobes of pronotum and pleura shiny. Tibiae little to moderately expanded apically. Coloration paler than in *sylvestre*, but top of head and disk of pronotum between the fasciae pale brown. Fasciae in every case reaching hind margin.

II. Intermediates between *P. t. tricolor* and *P. t. montana*.

(a) Four males and three females from Akaki Ravine (8. 9 N., 38. 8 E.), 6,500–7,000 ft., Oct., 1926 (*Dr. H. Scott*), and one female from "N. of Mt. Chilalo" (8 N., 39. 2 E.), Nov., 1926 (*H. Scott*). The males of this lot are slightly below the average size for *P. t. tricolor*, and the wings somewhat short. In one the fastigium approaches the condition in *montana*. In the others it is more or less similar to the Uganda series of *t. tricolor*. But the antennae and antennal joints are long. The females are slightly below the average size for *t. tricolor*, and the wings slightly shorter, the E/C ratio being rather low. Fastigium indistinguishable from typical *t. tricolor*. This series is undoubtedly much nearer to *t. tricolor* than to *montana*.

(b) Two males, one from Mulu, above Muger Valley (9. 3 N., 38. 2 E.), 8,000 ft., Dec., 1926 (*H. Scott*), and one from "near Addis Allem" (9. 0 N., 38. 3 E.), 8,000 ft., Sep., 1926 (*J. Omer Cooper*), resemble *montana* more closely, and it is significant that these localities are the nearest geographically to Wouramboulchi, from which the typical *montana* material was obtained. They are of similar size, the one from Mulu about average for *montana*, the other slightly larger; the wings are short, and the antennae shorter than in typical *t. tricolor*, though not as short as in typical *montana*. In the one from near Addis Allem, the fastigium approaches the condition in *montana*, while in the other it is similar to the Uganda series.

(c) Three males and one female from "C. Abyssinia," two males and the female from Lake Zwai (8 N., 38. 8 E.), June, 1914 (*O. Kovac*), and one male from Lake Horadaka, March, 1914 (*O. Kovac*), are nearer *P. t. tricolor* than *montana*. Intermediate in size, wings relatively shorter than in *t. tricolor*. Antennae longer than head and pronotum, the joints nearly twice as long as broad. Fastigium as in the Uganda series. Lateral pronotal fasciae not reaching the hind margin. In the female E/C is much too low for *t. tricolor*, falling in the *montana* range, but both head and wings are somewhat larger than in *montana*. L/P lies right outside the *montana* range, being little below typical *t. tricolor*.

(d) In a female from Zegi Tsana? (12 N., 37 E.), May and June, 1902

(*Degen*), both E/C and L/P are well within the *montana* range, but the whole insect, especially the head, is too large for *montana*, and the fastigium is typical for *t. tricolor*. Lateral pronotal fasciae not reaching hind margin.

III. Intermediates between *P. t. tricolor* and *P. t. sudanensis*.

Three males and three females from the southern shores of Lake Chad are intermediate. A male from Malari (*F. D. Golding*) resembles *sudanensis* in the pale coloration, but the hind tibiae are entirely bright red. Of two males from Kalkala (*A. M. Gwynn*), one is quite typical *sudanensis*, the other agrees in the pale colour, but the hind tibiae are entirely red, though not very dark. All the females are intermediate, but the distinguishing characters are not so definite in this sex.

IV. Intermediates between *P. t. tricolor* and *P. t. madecassa*.

The existence of a female with infero-internal and interno-median areas reddish from Morogoro, Tanganyika, has already been referred to. Another with these areas rather less red is recorded from Fort Johnston, Nyasaland. These may represent intermediates with *madecassa*.

V. Intermediates between *P. t. bisignata* and any other subspecies are unknown.

Distribution of *Paracinema*. (See map, p. 395.)

Summing up the facts concerning the distribution of *P. tricolor* which are contained in the lists of localities for each subspecies, it may be seen that its area of distribution comprises almost the whole of Africa and the Mediterranean region of south Europe, as well as Madagascar. The species is not known from Cirenaica or Egypt, nor from Palestine, though it occurs in western Anatolia.

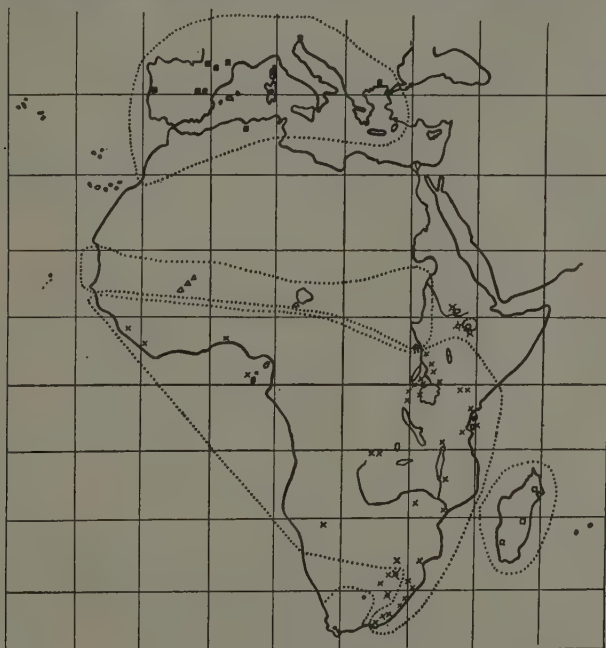
P. t. tricolor is the most widespread subspecies, inhabiting the whole of the continent south of lat. 10° N., with the exception of Abyssinia and the extreme south of the Union of South Africa. The subspecies forms a useful point of reference in considering both the morphological characters and the distribution of the others. The east coast records are very complete, with the exception of Somaliland, and though there are few records from the west coast south of the Equator, this paucity is no doubt due to the fact that these territories are foreign.

P. t. sylvestre appears to be confined to a small area of the Cape Province, comprising probably the winter-rainfall area in the south-west, and those parts of the Karroo where conditions are favourable. Intermediate forms between *t. tricolor* and *sylvestre* are found at points lying roughly on the boundary between the zones of distribution of the two subspecies (Aliwal North and Harrismith).

Typical *P. t. montana* occurs only, among the specimens I have been able to study, at Wouramboulchi. The other Abyssinian specimens are all more or less intermediate between this subspecies and *t. tricolor*.

P. t. sudanensis seems to be a more northern subspecies, occupying the strip of savannah and semi-desert country extending right across the continent between the northern limit of *t. tricolor* and the Sahara. There are few records from this region, but these are well distributed across the continent. On the southern shores of Lake Chad we find specimens intermediate between this subspecies and *t. tricolor*, so that this region presumably lies near the boundary between the zones of distribution of the two subspecies. The northern limit of *sudanensis* cannot be determined from the records available. It must be represented for the most part by the Sahara, but it is not known how far it may extend northwards up the west coast and the Nile Valley.

The Mediterranean subspecies, *P. t. bisignata* is represented in the material before me by specimens from the whole of southern Europe, including Corsica and Sardinia, and also from Algeria. It has also been recorded from western Anatolia, but not from Palestine or Egypt. Lucas, in his description of this form from Algeria, states that he had seen the same insect from St. Louis, in Senegal, but, as has already been pointed out, this record probably refers to another subspecies. There is no evidence of any contact, at the present time, between the zones of distribution of this subspecies and the rest.



EXPLANATION OF MAP.

- | | |
|-------|---|
| × | — records of <i>P. t. tricolor</i> . |
| ■ | — records of <i>P. t. bisignata</i> . |
| ● | — records of <i>P. t. sylvestre</i> . |
| △ | — records of <i>P. t. sudanensis</i> . |
| ○ | — records of <i>P. t. montana</i> . |
| □ | — records of <i>P. t. madecassa</i> . |
| | — approximate boundaries of the zones of distribution of the subspecies. |
| ■ | — records of forms intermediate between <i>t. tricolor</i> and <i>sylvestre</i> . |
| □ | — records of forms intermediate between <i>t. tricolor</i> and <i>montana</i> . |

Only three of the localities of the Madagascan subspecies have been identified on the map, and these lie one at the north-east, one at the south-west, and one in about the centre of the island, respectively. Apparently the whole island is populated.

P. luculenta is apparently a purely equatorial species. The original description is of a specimen from Togo, and there are specimens in the British Museum from various localities in Sierra Leone and Gold Coast. Sjöstedt's

material came from various localities in north-east Congo, but no records are known to me from further east.

Habitat. In all cases where information is available regarding the habitat of *P. tricolor*, this is found to be swamp or very damp vegetation. Definite information of this kind exists for all subspecies except *bisignata* and *montana*. Even where the habitat is not definitely stated, it may often be inferred from the locality. Thus nearly all the large African lakes provide records from their margins—Victoria, Nyasa, Chad, Tsana, Zwai, and several records are from rivers or their mouths—Zambezi, Niger. My own collecting has shown that the preferred habitat of *sylvestre* and *t. tricolor* consists of the cyperaceous reed borders of lakes and river estuaries. The insects are often found on reeds growing right out of the water, and swim readily. In this connection the expanded hind tibiae are of interest. It is clear that with such specialised habitat requirements the distribution of *P. tricolor* is unlikely to be influenced by the distribution of the main vegetation zones. Only where true desert conditions eliminate all water surfaces would life for the species become impossible. This is in fact the case. The species has been taken from regions of forest, savannah, grassland and the semi-desert Cape Karroo.

The use of biometric methods in separating the subspecies.

Uvarov, in attempting to obtain a numerical expression of the differences between the two "species" of the genus *Locusta* L., first introduced into the systematics of the ACRIDIDAE the method of biometric analysis. Later, with the almost universal acceptance of his Phase Theory, this method has been widely used by various authors (Faure, Zolotarevsky, Johnston, Lean, etc.) for characterising the phases of locusts, and for separating the subspecies of *Locusta*. The method is a statistical one, and involves the taking of measurements and the calculating of ratios between them which seem likely to show a range which will be characteristic for a group.

Measurements of the following characters were taken: Length of elytron from the point where the anal vein approaches nearest to the ulnar vein, at the base of the elytron (E); breadth of head from above at its widest point (C); length of pronotum along the median carina (P); length of antenna (L); and smallest distance between lateral fasciae of pronotum (B). The following ratios were then calculated: E/C, L/P, P/B. These ratios were found to give the best expression of the various quantitative differences between the subspecies, and, taken together, are often characteristic for each subspecies. To save labour, only the females were measured: the males can be distinguished on other characters more readily than the females. All measurements were taken by means of dividers and a scale graduated in $\frac{1}{2}$ mm., except in the case of the smallest distance between the pronotal fasciae, which was measured under binoculars with a squared eye-piece, and were expressed to the nearest 0.1 mm. In the case of very long series, not more than 20 females were measured. Measurements were taken both of series typical for the various subspecies, and of series or individuals which were intermediate.

These ratios have been referred to in the descriptions of the subspecies, and in Tables 1 and 2 the maximum and minimum and the average are given for each measurement and ratio, for each subspecies and for various intermediate series. A consideration of these figures will indicate the manner in which they can be used to distinguish between the subspecies.

Referring first to the values for E/C (Table 1), it is seen that in *sylvestre* the whole range lies below the values for any other subspecies; i.e. the maximum

value for *sylvestre*, 5.476, is less than the minimum value for the whole of the rest of the series, viz. 5.674 in *madecassa* (series 2). In this case, therefore, the ratio E/C is by itself sufficient to enable a complete separation to be made between *sylvestre* and the other subspecies. It is the only case in which this is possible. There are two cases in which one ratio enables complete separation of one subspecies from one or more others, but not from all. Thus the ratio L/P separates completely *montana* and *bisignata* from *t. tricolor* and *madecassa* (series 1); and the ratio P/B separates completely *sylvestre* from *bisignata*. In other cases there is a very nearly complete separation between the ranges for two subspecies: e.g. in P/B there is very little overlap between *t. tricolor*, *sudanensis* and *montana*, on the one hand, and *bisignata* on the other.

TABLE 1.
Biometric ratios of the subspecies of *P. tricolor*.

Subspecies.		E	C	E/C	P	L	L/P	B	P/B
<i>t. tricolor</i> (21)	min.	31.1	4.7	6.034	6.0	9.4	1.417	2.04	2.642
	av.	35.47	5.38	6.647	7.09	11.34	1.631	2.34	3.032
	max.	38.75	5.8	7.046	8.1	14.4	1.972	2.55	3.649
<i>sudanensis</i> (18)	min.	31.5	4.9	5.962	6.5	9.0	1.363	1.92	2.933
	av.	34.57	5.30	6.521	6.93	10.53	1.511	2.09	3.301
	max.	39.5	5.6	7.181	8.0	12.5	1.677	2.40	3.593
<i>bisignata</i> (21)	min.	29.2	4.4	5.900	6.6	8.1	1.126	1.62	3.333
	av.	31.59	4.81	6.557	6.96	9.06	1.287	1.83	3.814
	max.	35.3	5.3	6.988	7.75	9.9	1.412	2.16	4.305
<i>sylvestre</i> (12)	min.	23.2	4.4	4.884	5.4	7.6	1.263	1.86	2.571
	av.	24.82	4.75	5.228	5.77	8.31	1.426	1.99	2.894
	max.	26.2	5.0	5.476	6.25	9.2	1.527	2.10	3.021
<i>madecassa</i> (1) (23)	min.	26.75	4.0	6.261	5.4	8.4	1.452	1.65	2.980
	av.	30.29	4.52	6.687	6.28	9.12	1.542	1.96	3.222
	max.	33.7	4.9	7.199	6.8	9.5	1.611	2.22	3.720
<i>madecassa</i> (2) (20)	min.	23.0	4.0	5.674	5.0	7.25	1.288	1.80	2.658
	av.	26.95	4.44	6.062	6.00	8.42	1.423	2.03	2.964
	max.	29.75	4.75	6.555	6.5	9.7	1.644	2.25	3.334
<i>montana</i> (12)	min.	23.0	3.75	5.800	5.25	4.75	0.819	1.56	2.882
	av.	24.85	4.01	6.200	5.88	6.89	1.173	1.84	3.215
	max.	27.0	4.25	6.512	6.4	8.1	1.371	2.22	3.555

The numbers appearing below the name of each subspecies refer to the number of specimens measured. All figures refer to females only.

Usually, however, one cannot rely upon one ratio alone but must use all three before a complete characterisation of the subspecies is obtained, and sometimes even all three are not adequate to effect a complete separation. Thus *bisignata* is the only subspecies which has very high P/B, high E/C, and low L/P; *montana* is the only one which has very low L/P, medium E/C, and medium P/B. The subspecies most difficult to separate by means of the ratios, viz. *t. tricolor*, *sudanensis* and *madecassa* (series 1) are those most readily separable on colour characters.

In addition to the ratios, any one of the absolute measurements may be used

TABLE 2.

Biometric ratios of various intermediate and atypical series.

Series.	E	C	E/C	P	L	L/P	B	P/B
Various specimens close to <i>t. tricolor</i>	37.9	5.7	6.648	7.2	—	—	—	—
	36.25	5.5	6.591	7.0	10.0	1.429	—	—
	34.9	5.0	6.980	6.7	—	—	—	—
	34.0	4.9	6.939	7.1	—	—	—	—
	34.1	5.2	6.558	7.0	—	—	—	—
	32.2	5.1	6.314	6.9	10.75	1.558	—	—
	27.0	4.3	6.279	5.6	—	—	—	—
	32.2	5.1	6.314	6.75	—	—	—	—
	27.9	4.25	6.564	5.8	8.4	1.448	—	—
	31.8	4.75	6.694	6.2	—	—	—	—
	29.0	4.5	6.445	6.1	—	—	—	—
	34.75	5.25	6.618	7.0	10.4	1.486	—	—
	33.0	4.8	6.876	6.8	—	—	—	—
	29.6	4.8	6.167	7.0	—	—	—	—
	28.9	4.5	6.422	5.9	9.3	1.576	—	—
	25.75	4.25	6.059	5.5	9.0	1.636	—	—
	29.5	4.5	6.555	6.1	9.4	1.541	—	—
	29.75	4.2	7.084	6.2	—	—	—	—
	33.7	5.2	6.480	6.4	10.4	1.625	—	—
	29.1	4.5	6.468	6.2	9.2	1.484	—	—
	34.6	5.1	6.784	7.0	11.8	1.686	—	—
	32.7	4.75	6.884	6.7	10.3	1.537	—	—
	31.6	4.5	7.023	6.4	—	—	—	—
	29.9	4.6	6.500	6.6	9.5	1.440	—	—
	31.1	4.4	7.068	6.5	8.6	1.323	—	—
	33.1	5.0	6.620	6.6	10.4	1.576	—	—
	27.75	4.25	6.530	5.5	7.25	1.318	—	—
	27.1	4.3	6.302	5.5	—	—	—	—
	37.1	5.5	6.745	7.0	11.7	1.671	—	—
Deelfontein series (near <i>sylvestre</i>)	23.2	4.0	5.800	4.7	7.5	1.596	1.80	2.611
	24.0	4.25	5.646	4.9	6.8	1.388	1.92	2.552
	23.1	4.3	5.371	5.0	8.1	1.620	1.80	2.777
Aliwal North (near <i>sylvestre</i>)	28.6	5.0	5.720	6.3	9.5	1.508	2.16	2.916
	29.4	4.75	6.189	6.5	10.0	1.538	1.98	3.283
Algeria (<i>bisignata</i>)	29.7	4.5	6.601	6.1	—	—	1.44	4.236
Inter <i>t. tricolor</i> and <i>montana</i> (a) & (b)	29.8	4.9	6.081	6.75	8.8	1.304	—	—
	28.3	4.5	6.290	5.6	8.6	1.536	—	—
	30.5	4.7	6.489	6.5	10.6	1.631	—	—
	26.9	4.7	5.724	6.1	9.4	1.541	—	—
The same (c) & (d)	28.2	4.7	5.999	5.75	8.5	1.478	—	—
	28.75	4.9	5.868	6.5	7.5	1.154	—	—
Inter <i>t. tricolor</i> and <i>sudanensis</i> (Nigeria)	35.6	5.3	6.716	6.9	10.0	1.450	—	—
<i>P. t. madecassa</i> : series 4, av. (2) series 5, av. (5) series 3, av. (12)	28.1	4.5	6.244	6.0	9.5	1.557	—	—
	27.4	4.4	6.287	5.77	—	—	—	—
	28.1	4.4	6.400	5.9	8.3	1.416	—	—

All the above figures refer to single specimens, except those for *madecassa*.

as a measure of absolute size, and separation may be attained by this means, or in conjunction with the ratios. For example, *montana* and *sylvestre* are completely separated from *t. tricolor*, *sudanensis* and *bisignata* by means of the values for E.

TABLE 3.

Biometric ratios of three specimens of *P. luculenta* in the British Museum, and of Sjöstedt's female paratype of *P. guilielmi*.

Species.	E	P	C	E/C	E/P	P/C
<i>P. luculenta</i>	26.2	6.25	5.1	5.137	4.192	1.226
	31.75	7.4	5.9	5.381	4.291	1.254
	27.75	6.4	5.2	5.337	4.336	1.231
<i>P. guilielmi</i>	23.6	6.0	4.8	4.917	3.933	1.250

The figures refer to individual specimens. E/P has been calculated in place of I/P, since the antennae are broken in most of the insects.

The calculation of the standard deviation suggests itself as a more accurate method of treating these biometric data, but I do not regard it as a method worth pursuing, for two reasons: first, it is over-accurate, and would show differences between many natural populations which no specialist would regard as distinct subspecies, and the problem of how great a difference from the standard deviation should be considered as indicating specific or subspecific validity would remain; secondly, sufficient material to justify the use of statistical methods at all is very rarely available to systematists, and, even if it were, it is improbable that there would be many prepared to make use of so laborious a method.

A consideration of Table 2 shows that the intermediate character of certain series extends to the ratios also, and that if these intermediate series be included there is no definite line of demarcation between many of the subspecies.

In Table 3, measurements and ratios of a few females of *P. luculenta* are given, for the sake of completeness.

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